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Stress Relaxation of Cellular Silicone Material: 1980

By J. W. Schneider

Published September 1980

Topical Report

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Topical Report
J. W. Schneider, Project Leader

Technical Communications

Bendix

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Bendix Kansas City currently is evaluating the long-term (10 years) stress relaxation properties of cellular silicone materials at room temperature. The cellular structure is formed by using urea as a leachable filler. Both equilibrium (random copolymer) and condensation (block copolymer) type base polymers are included. Each material was compounded to yield two different densities for several thickness combinations. These density-thickness combinations then were compressed to nominal compressions of 20 and 40 percent with nine replicates at each condition. Five are tested regularly, two are 3 year controls, and two are 10 year controls. A specially-designed fixture is used to maintain a specific compression on the cellular sample, and a universal test machine is used to acquire the load data. The load was recorded at initial assembly and at selected times thereafter. The present data have been generated for equilibrium-type materials stored 5 years and condensation-type materials stored 4 years.

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SUMMARY

Bendix Kansas City currently is involved in generating stress relaxation information for cellular silicone materials that are formed with urea leachable filler. There are two types of base polymers used in the test: equilibrium type (random copolymer) and condensation type (block copolymer). Each of these was compounded to provide finished materials with nominal apparent densities of 0.34 and 0.52 g/cm^3. Three sample variations of 1.17, 1.52, and 2.54 mm nominal thickness were prepared from the lower density product, and two sample variations of 1.52 and 2.54 mm nominal thickness were prepared from the higher density product. Each of the material/thickness combinations was compressed to nominal compressions of 20 and 40 percent, with nine replicates at each condition.

A specially designed compression fixture for aging is used to maintain a specific compression on the cellular sample at room temperature, and a universal test machine is used to acquire the load data. The load was recorded at initial assembly and at selected times thereafter. In all, a total of 180 specimens are in test, 90 equilibrium type material samples that have been stored 5 years and 90 condensation type material samples that have been stored for 4 years. Each condition for each material type has nine replicates. Of these nine samples, two are 3 year controls, two more are 10 year controls, and five are tested regularly.

The current data still support the statement that the time dependent loss of load bearing properties is approximately log-linear, with the major differences found to be between the material types and between the two densities of each material type. Extrapolation indicates that at the end of the planned 10-year study, the load retention of all samples will be between 57 and 66 percent of original; the condensation type material is expected to be superior.

DISCUSSION

SCOPE AND PURPOSE

Cellular silicone cushions act as gap fillers to allow for space left from manufacturing tolerances and thermal expansion of adjacent components. For the cushions to be able to perform this job, they are required to exert a specific compressive force at predetermined maximum and minimum gaps. Because the cellular silicone cushion must do this job of gap filling for the life of the component, the purpose of this project is to gather information about the long term stress behavior of the cushion under load.

ACTIVITY

The aging fixtures used in this study are compatible with a universal test machine. Each cushion sample is aged in its own fixture (Figure 1). With the fixture installed on the test machine, the load bearing properties of the material can be checked at selected time intervals. The assembled aging fixture seen on the left side in Figure 1 has a threaded stud that screws into the actuator rod of the test machine. The six nuts and bolts also seen in this view maintain the clamping force on the cushion sample while aging. Also, the four cap screws in this view hold a removable detail (plug) that can be changed to vary the amount of compression placed on the sample. This cavity and cushion sample can be seen in the right hand view of Figure 1.

A total of 180 specimens are in test: 90 equilibrium type (random copolymer) samples (material in use now) that have been stored 5 years, and 90 condensation type (block copolymer) samples (material for future use) that have been stored 4 years. Each type of material was compounded to yield nominal apparent densities of 0.34 and 0.52 g/cm^3. Three sample variations of 1.17, 1.52, and 2.54 mm nominal thickness were prepared from the lower density product, and two sample variations of 1.52 and 2.54 mm nominal thickness were prepared from the higher density product. Each of the material/thickness combinations was compressed to nominal compression of 20 and 40 percent. There are nine replicates at each condition; five are tested regularly, and four are control samples.

The initial procedure for testing was to place the lower half (stud side) of the fixture into the load frame and place a 50.8-mm-diameter disc of cushion in the center of the cavity. The remaining half of the fixture is aligned and set on the sample. A small controlled amount of preload is applied to maintain contact between the fixture and the test machine load

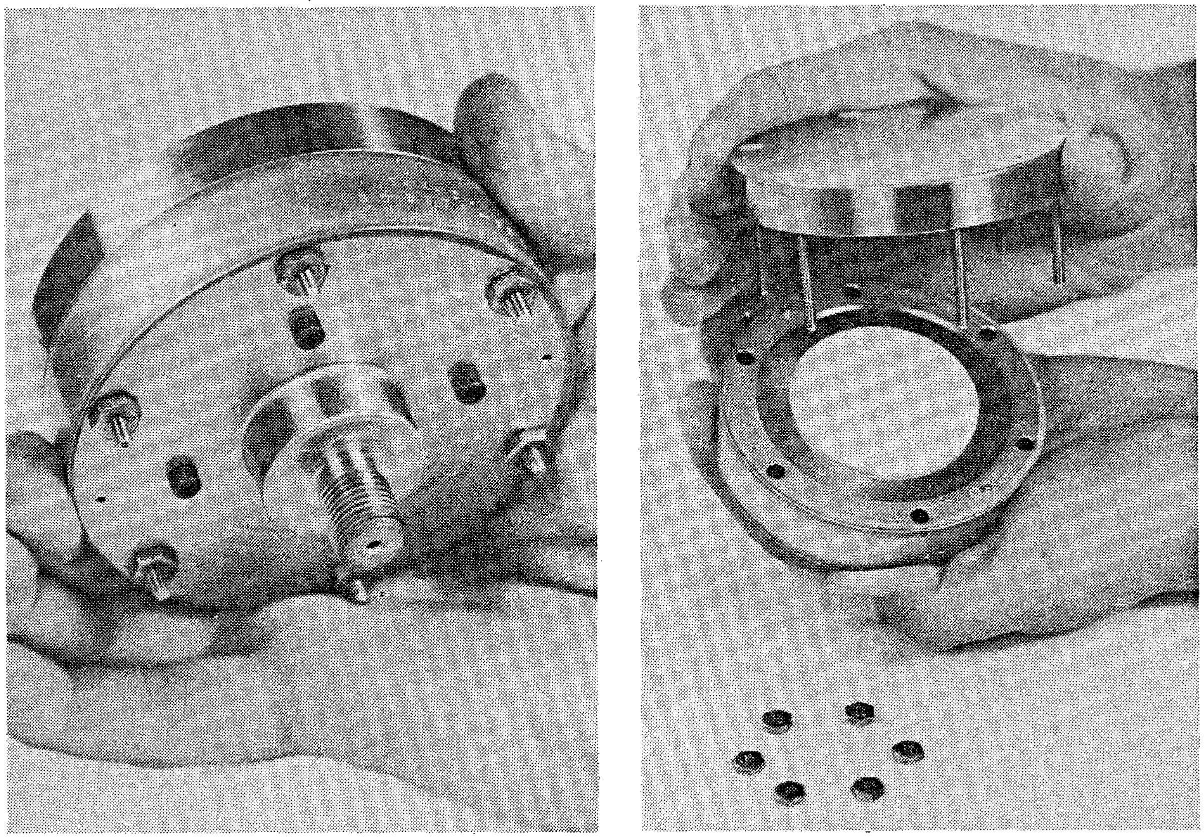

Figure 1. Compression Fixture for Aging of Material

cell. Force is the feedback variable in this test; increasing force on the fixture is applied at a constant rate up to and beyond fixture closure. At this point, the loading is reversed until the preload is the only force, and the unloading is reversed to return the fixture well beyond fixture closure. Then, the unloading-loading sequence is repeated. Holding the load at this point, the six retaining nuts are placed back on the fixture to maintain this compression on the cushion sample until the sample is checked again. The fixture is then removed, and a new fixture can be assembled. Typical results from the initial assembly testing are shown in the upper set of curves in Figure 2.

The lower set of curves in Figure 2 is a typical result of later testing. The testing sequence in this case is identical to that of the assembly steps with the exception of the starting point. Assembled fixtures are placed in the load frame and a force greater than the closing force is applied. The six retaining nuts are loosened and removed and the test continues in the same manner as before. The sample is cycled three times and then is locked up until the next testing.

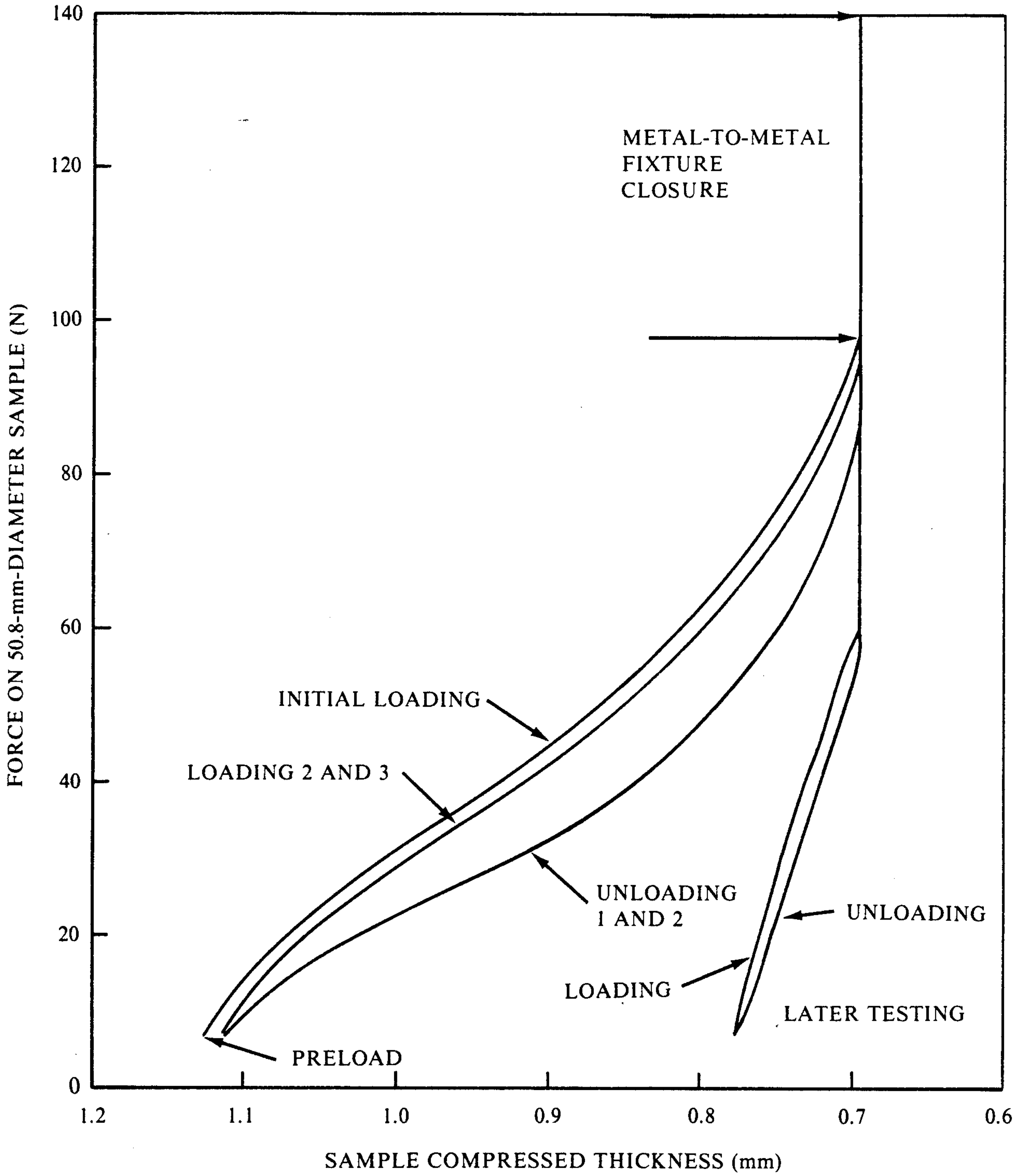

Figure 2. Typical Loading and Unloading Curves, Normal Scale, at Initial Loading and Later Testing

Two pieces of information are available from the two sets of curves. One is the force exerted by the sample at fixture closing, and the second is the thickness of the sample at minimum load (preload).

Figure 2 shows that determining the closure load with any precision is difficult. For this reason, the actual measurement is obtained by using an amplified displacement scale (Figure 3). As before, the upper curve is the assembly loading and the lower set the aged loading. To determine the closure load, a line tangent to the loading curve, between 0.025 and 0.0025 mm prior to closure, is drawn and its intersection with the vertical closure line is read. By dividing the value obtained for the aged sample by the value obtained for the initial assembly load, a percent retention can be calculated. These data are plotted versus the log of the time in assembly, as shown in Figures 4 through 7. All the data points were used to determine a single straight line approximation, by the method of least squares, for each material type and each density. The results of the previous test are shown by the dashed line. Curves comparing the current trends are plotted together in Figure 8. The equilibrium type material at 0.34 g/cm^3 seems to have the greatest drop in load retention projected for the 10-year study.

The material comparison data reported for 1979 was incorrect. The equilibrium type material at 0.34 g/cm^3 has a much lower 10-year load retention value than was reported.[1] A corrected graph comparing the four materials is given in Figure 9.

Compressed thickness measurements at the minimum load were recorded as a side benefit. The measured values of the aged samples along with the measured values at assembly were used in a standard compression set formula. The value calculated previously was named[1] effective compression set. These data are plotted versus the time in assembly and shown in Figure 10.

ACCOMPLISHMENTS

The rate of load loss for both densities of condensation type material is approximately the same. The load retention value, projected to the end of the study, for the higher density equilibrium type material is approximately the same as for the lower density equilibrium material. The rate of load loss for the equilibrium material at 0.34 g/cm^3 indicates this material may drop below the load retention of the 0.52 g/cm^3 equilibrium type material by the end of the 10-year time period. Currently, the predicted percent retention of load is between 57 and 66 percent of original load, with the condensation type material having a higher load retention value. The condensation type material is also the lower effective compression set material.

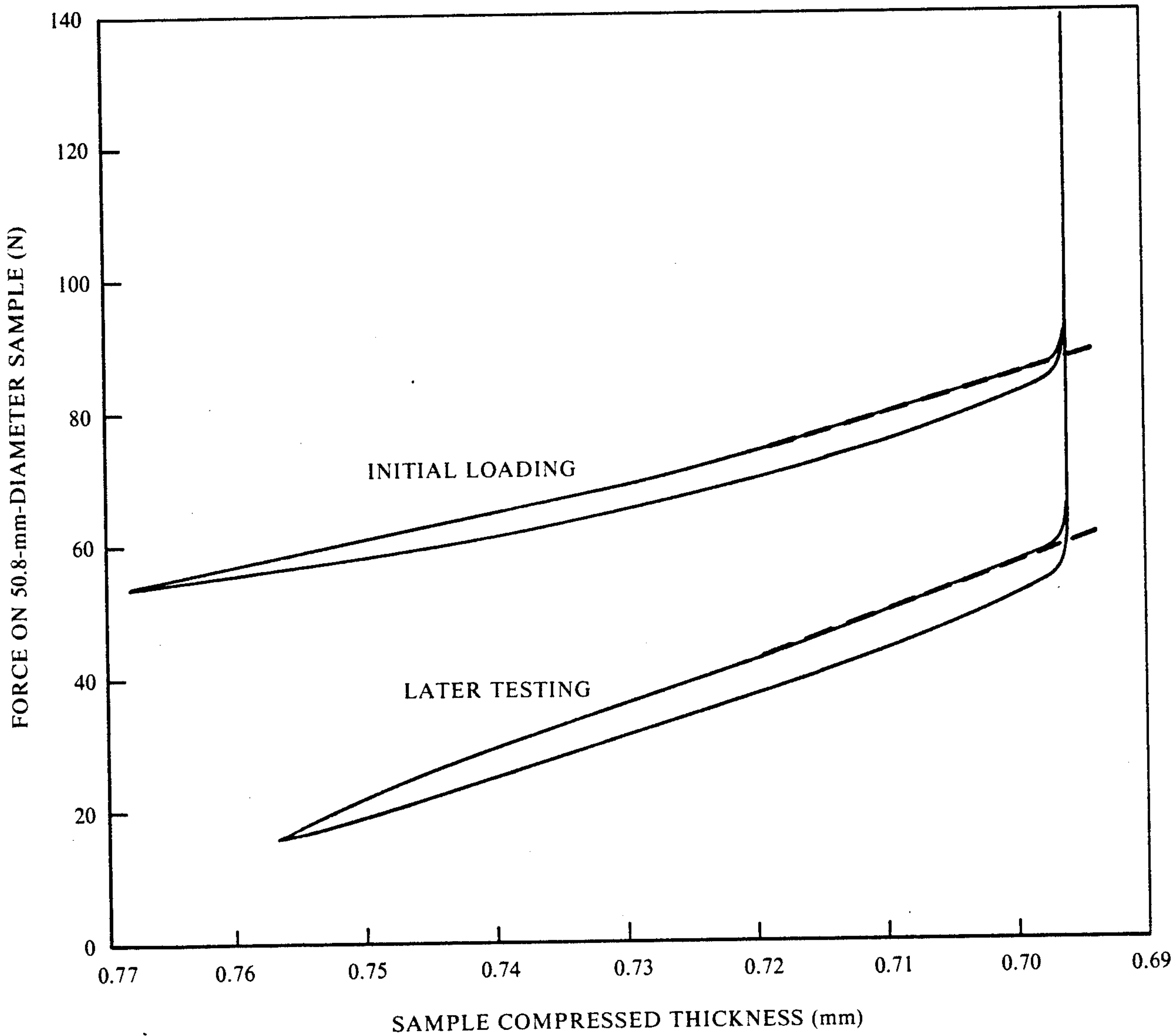

Figure 3. Typical Loading and Unloading Curves, Expanded Scale With Tangent Drawn, at Initial Loading and Later Testing

FUTURE WORK

The samples will continue to be monitored regularly until the completion of the 10-year plan. A new material, 0.64 g/cm^3 nominal density condensation type, may be added to the study.

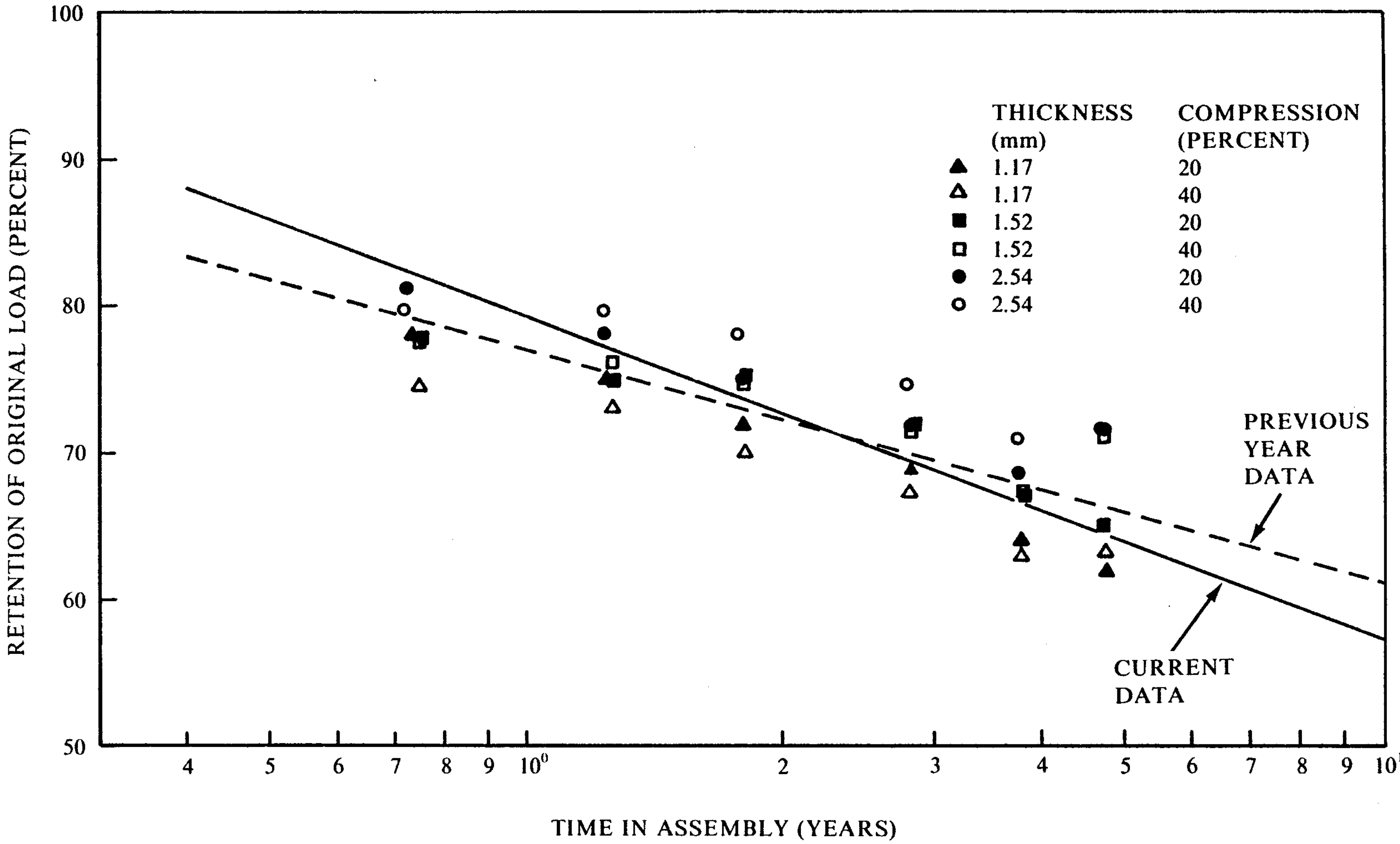

Figure 4. Percent Retention Versus Log Time for Equilibrium Type Material, 0.34 g/cm^3 Nominal Density

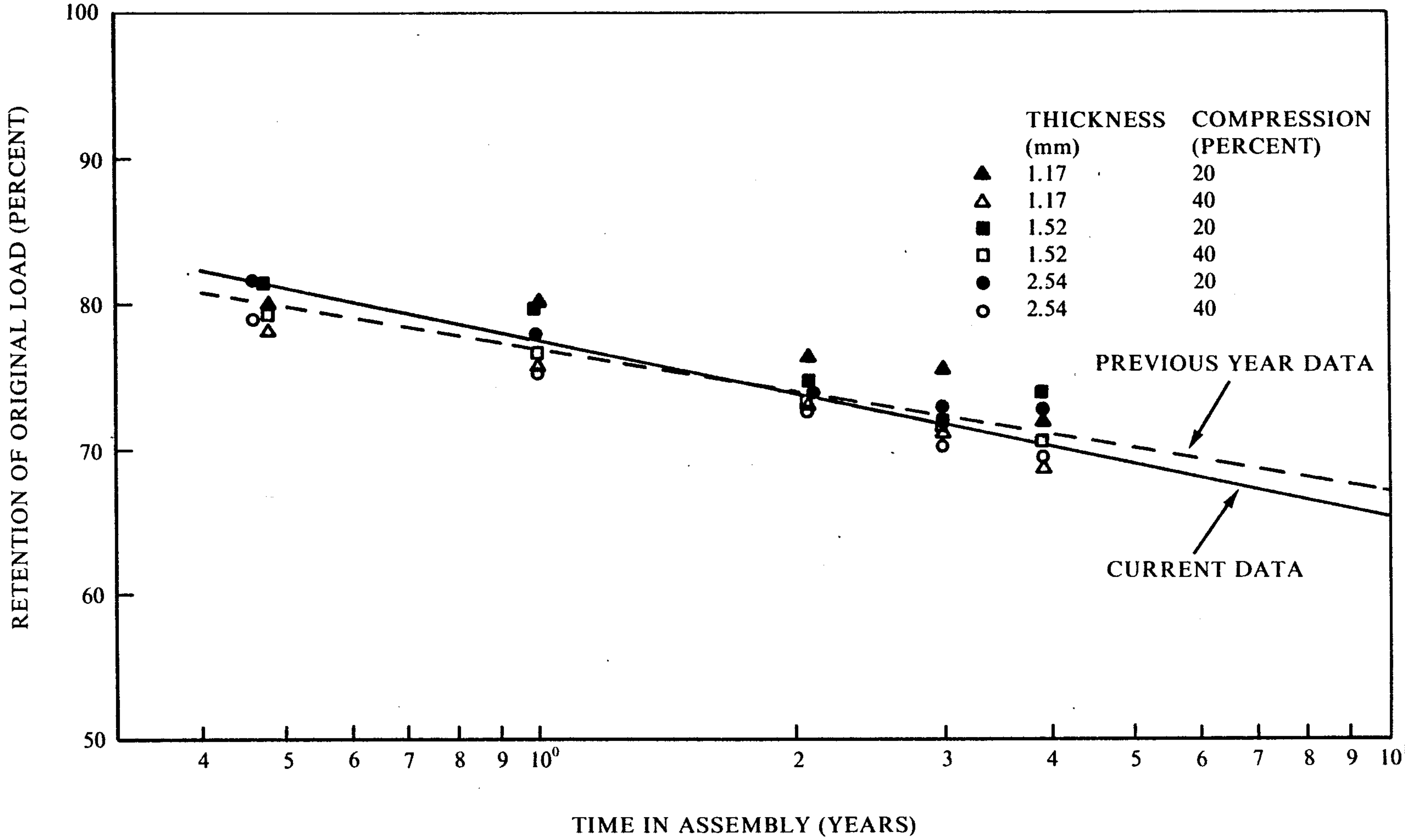

Figure 5. Percent Retention Versus Log Time for Condensation Type Material, 0.34 g/cm^3 Nominal Density

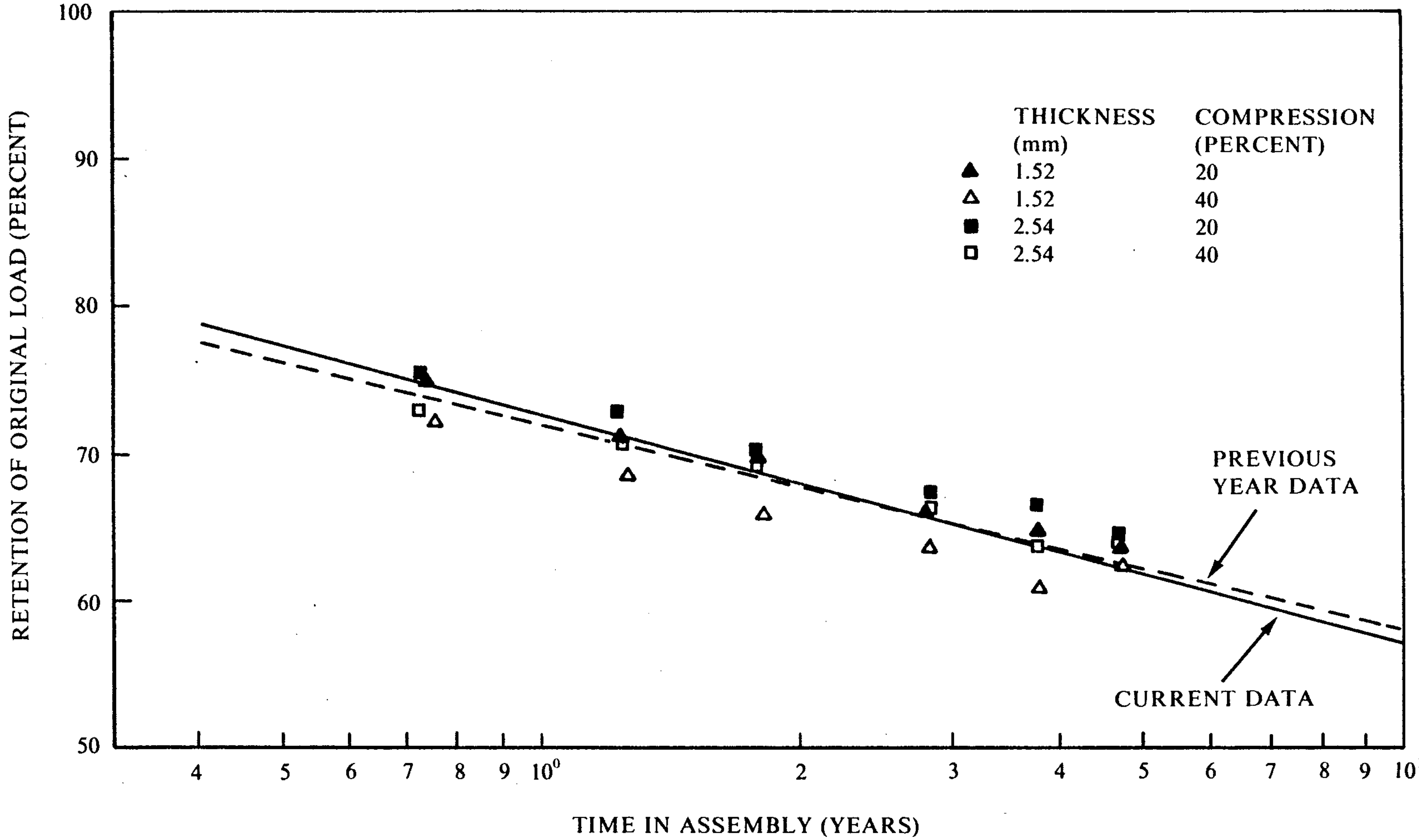

Figure 6. Percent Retention Versus Log Time for Equilibrium Type Material, 0.52 g/cm^3 Nominal Density

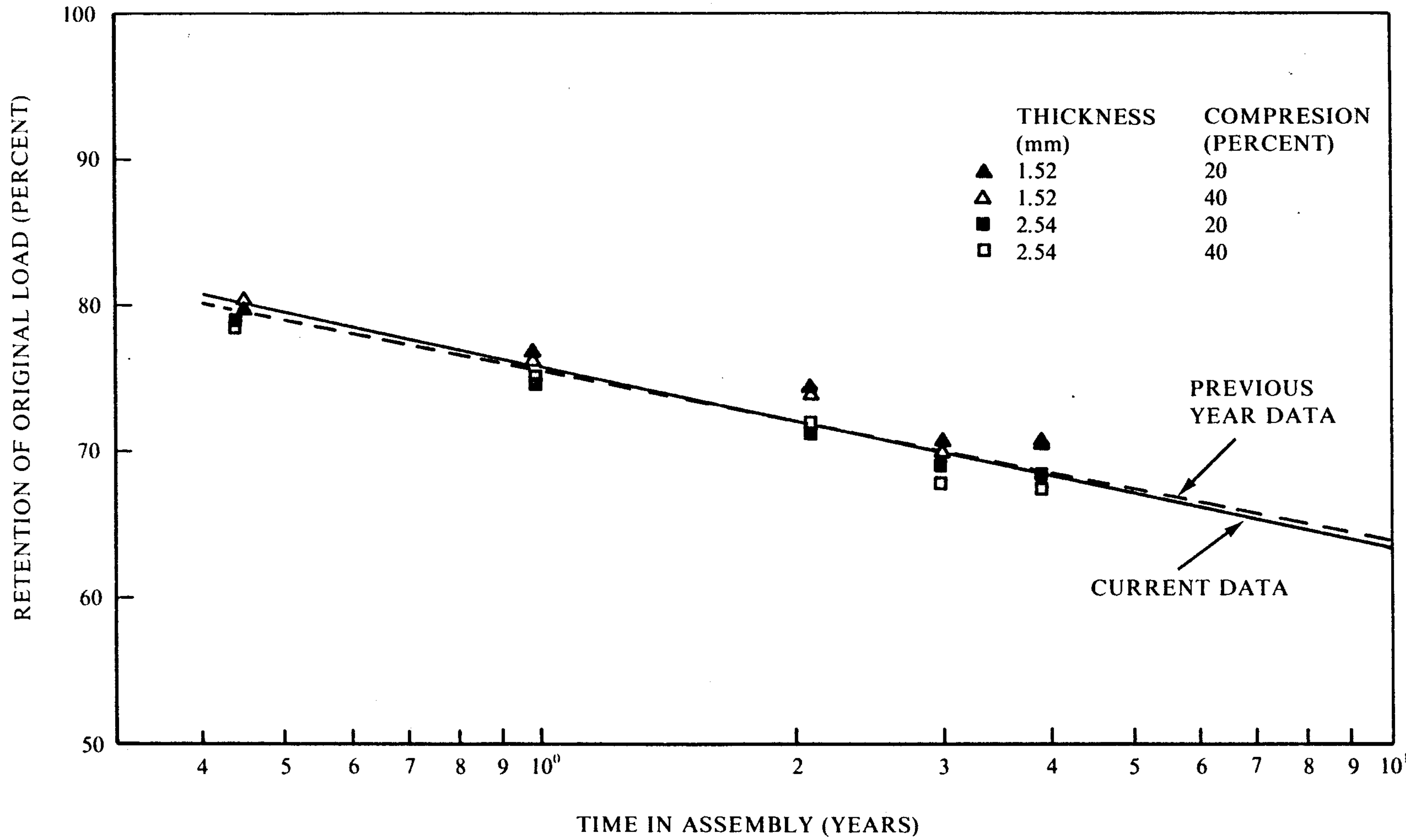

Figure 7. Percent Retention Versus Log Time for Condensation Type Material, 0.52 g/cm^3 Nominal Density

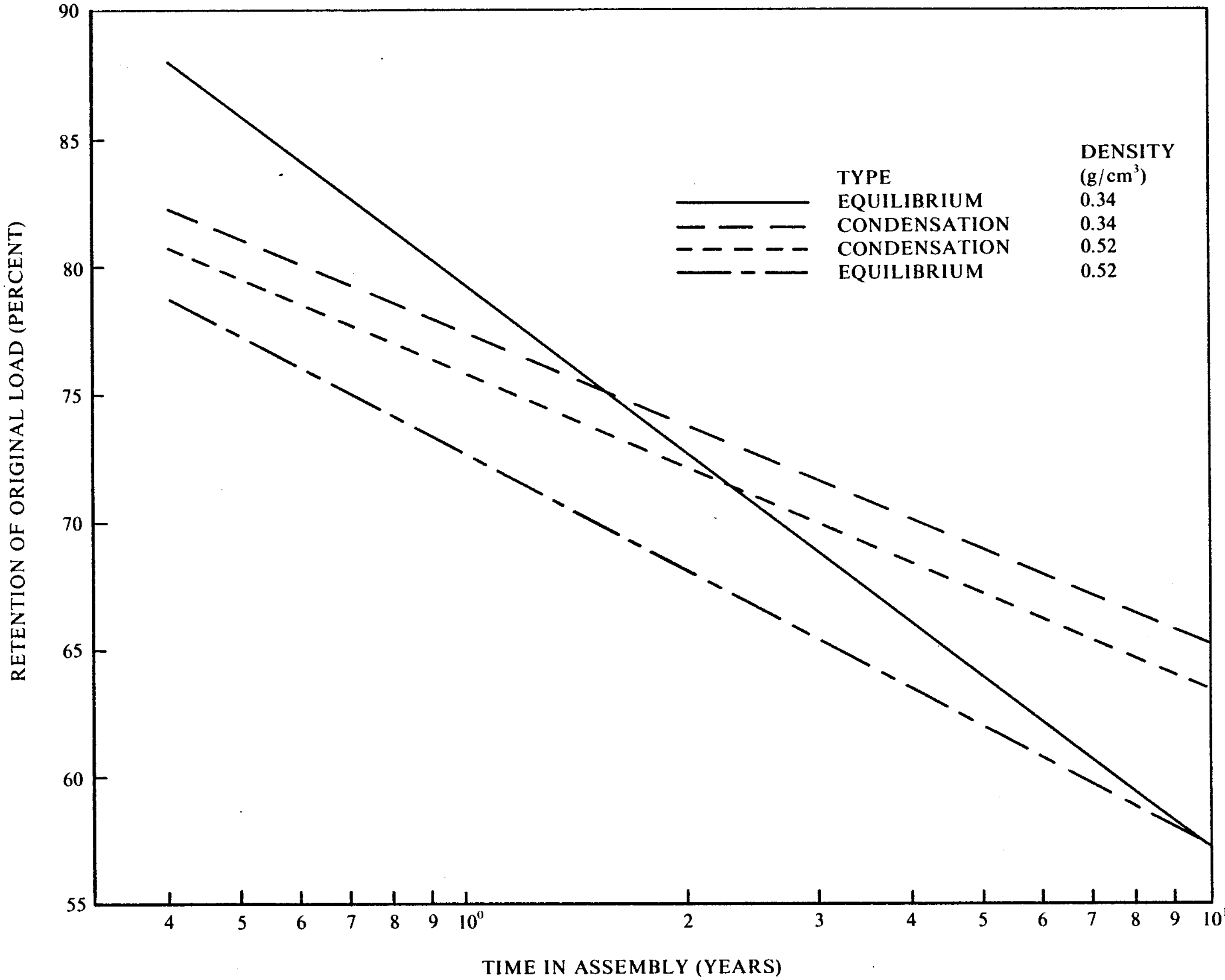

Figure 8. Percent Retention Versus Log Time, Comparison of Materials

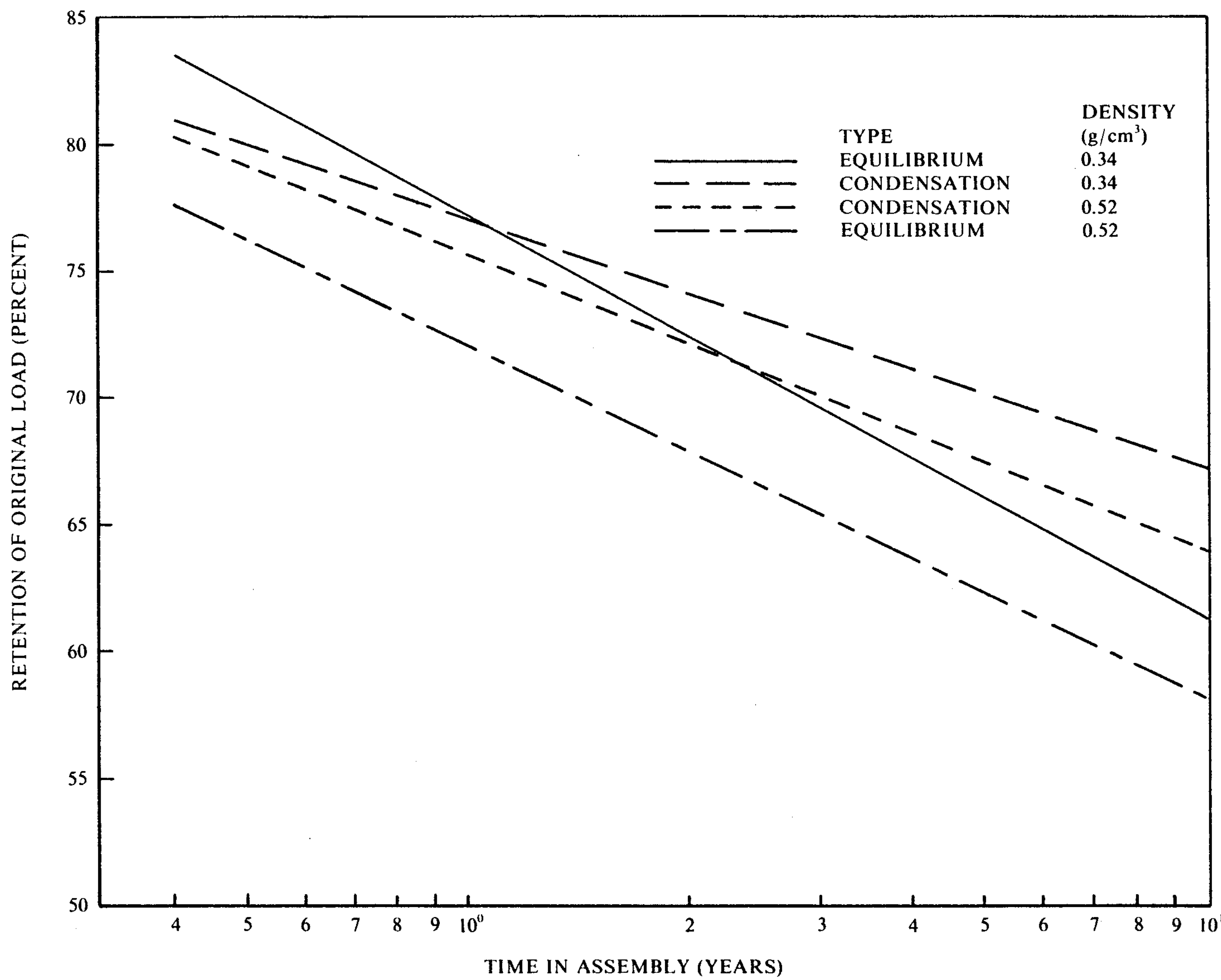

Figure 9. Percent Retention Versus Log Time, Comparison of Materials (Corrected Data for August 1979)

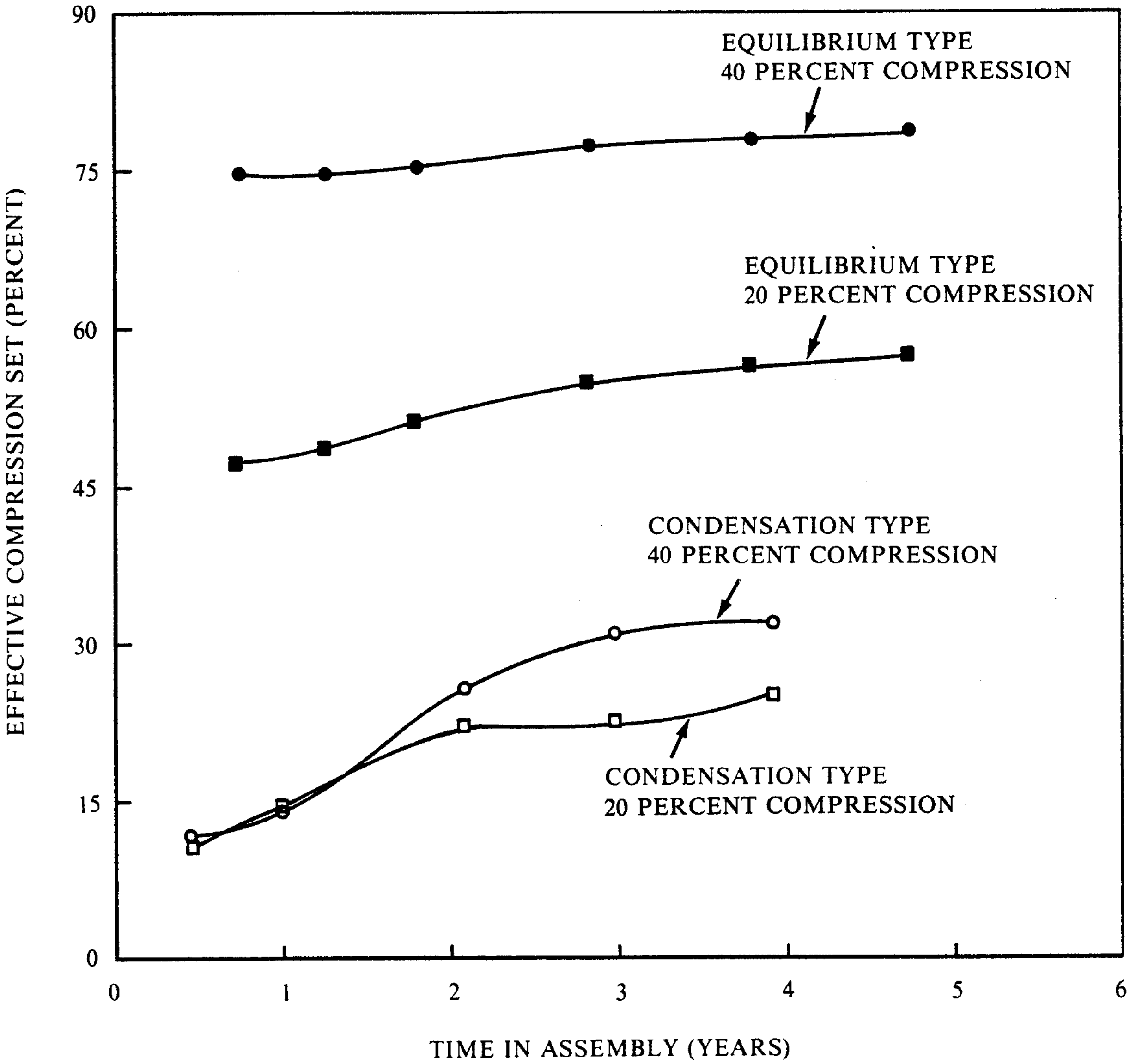

Figure 10. Effective Compression Set Versus Aging Time

REFERENCE

[1]J. W. Schneider, Stress Relaxation of Cellular Silicone Material (Topical Report). Bendix Kansas City: BDX-613-2399, May 1980 (Available from NTIS).

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PLASTICS: Stress Relaxation

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